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Risk-Based Capital Standards, Deposit Insurance and Procyclicality

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Abstract

This article shows that risk-based deposit insurance premiums generate smaller procyclical effects than do risk-based capital requirements. Thus, Basel II's procyclical impact can be reduced by integrating risk-based deposit insurance. If deposit insurance is structured as a moving average of contracts, its procyclical effects can be decreased further. Empirical illustrations of this are presented for 42 banks over the period 1987 to 1996. The results confirm that lengthening the contracts' maturities intertemporally smoothes premiums but raises the average premium level needed to compensate the insurer for greater systematic risk. The distribution of risk-based premiums across banks is skewed.

Key Words: capital standards, deposit insurance, procyclical

JEL Classification: G21; G22; G28

CFR Research Programs: deposit insurance, bank regulatory policy.

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Risk-Based Capital Standards, Deposit Insurance, and Procyclicality

1. Introduction

The New Basel Capital Accord (Basel II) increases the sensitivity of a bank's capital requirement to the risk of its assets. This reform of the 1988 Basel Accord has been criticized for creating incentives that could make bank lending more procyclical.[1] During recessions, loan losses reduce bank capital and, even if capital requirements are insensitive to risk, a capital-deficient bank must increase its capital ratio. In addition, recessions tend to raise the default risk of loans, and Basel II's more refined risk-based standards would further pressure banks to strengthen their capital ratios.[2] This response of capital ratios to default risks can reduce banks' incentives to lend during a recession and worsen economic activity. Thus, capital requirements as envisioned under Basel II could increase macroeconomic instability. However, this assertion is based on examining the effect of risk-based capital requirements largely as an isolated instrument, as opposed to merely one component of regulation. The question this raises is whether procyclicality is inevitable under risk-based capital standards or whether there are other features of regulation that may attenuate it.

I address this question by adding risk-based deposit insurance premiums to the mix. I show that the procyclical impact of risk-based capital requirements can be mitigated by this additional instrument of bank regulation. I argue that if risk-based insurance premiums were integrated with risk-based capital requirements, bank regulation would create fewer distortions and would emulate the market discipline that investors impose on non-banking firms. In addition, if deposit insurance is structured as a moving average of long-term contracts, the procyclical

[1] Basel II is scheduled to take effect in 2007. Its potential to amplify the cyclicality of capital requirements is well-recognized. See, for example, Danielson et al. (2001), Lowe (2002), and Ayuso et al. (2004). Dangl and Lehar (2004) and Decamps et al (2004) analyze the effects of Basel II on banks' risk-taking incentives.

[2] Kashyap and Stein (2004) conduct an empirical study and review several others that estimate the cyclicality of capital requirements under Basel II. They conclude that Basel II's impact can be large and economically significant.

effects of bank regulation can be reduced further. I show that a moving average structure for deposit insurance decreases the volatility of premiums over the business cycle. This reduction in volatility is quantified using data from 42 individual banks during the period 1987 to 1996. The empirical results indicate a trade-off between intertemporally smoothing premiums and the average level of premiums that banks should pay.

The premise of my analysis is that bank regulation should meet its goals while avoiding subsidies that could distort the financial system. The primary goal of bank regulation is to protect small, unsophisticated depositors and thereby prevent bank runs and their monetary consequences. To achieve this goal, many countries have established deposit insurance, which then requires additional policies to control insurance losses and to avoid subsidization of the deposit insurance "safety net." An explicit objective of the original Basel Accord is to prevent safety net subsidies that would provide a competitive advantage to one country's banks over another's.[3] Preventing safety net subsidies also ensures that banks face a level playing field as they increasingly compete with non-bank providers of financial services.

Policies for controlling a government's deposit insurance exposure include risk-based capital requirements, risk-based deposit insurance premiums, and market discipline by holders of uninsured bank debt. Market discipline and risk-based premiums are similar in that both require banks to pay default-risk premiums on their liabilities, thereby reducing the incentive for excessive risk-taking. Moreover, risk-based insurance reinforces market discipline because it reduces a bank's incentive to substitute insured deposits for uninsured debt when its risk increases.[4] Hence, the mechanisms for controlling a government's exposure to bank losses

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[3] As stated in Basel Committee on Banking Supervision (1988), its regulatory framework should be "fair and have a high degree of consistency in its application to banks in different countries with a view to diminishing an existing source of competitive inequality among international banks."

[4] Substantial empirical evidence, such as Billett, Garfinkel, and O'Neal (1998) and Shibut (2002), documents that financially distressed banks replace uninsured liabilities with risk-insensitive insured deposits.

effectively come down to making bank capital risk-sensitive and/or making bank liabilities risk-sensitive.[5]

Flannery (1991) argues that if a government wishes to minimize deposit insurance subsidies, regulation must incorporate both risk-based capital requirements and risk-based deposit insurance premiums. His analysis assumes that regulators cannot measure a bank's risk with perfect accuracy, but that they estimate the bank's asset value and asset volatility with error. To [6]reduce the variance of the government deposit insurer's liability or, equivalently, the variance of the net subsidy provided by deposit insurance, he shows that both capital requirements and deposit insurance premiums need to vary as a function of the measured level of bank risk. An implication of his analysis is that it is best to employ both risk-based capital requirements and risk-based insurance premiums to achieve the Basel Accord's objective of leveling the playing field for banks in different countries.

This article also advocates an integration of risk-based deposit insurance with risk-based capital standards, but based on the novel argument that doing so reduces procyclicality. Given the premise that deposit insurance should be subsidy-free or "fair," I show that the procyclical impact on banks from setting risk-based deposit insurance premiums is lower than the procyclical impact from setting risk-based capital requirements. The implication is that, from a procyclicality point of view, it is better to allow both insurance premiums and capital requirements to vary over the business cycle rather than fix insurance premiums and vary only capital requirements.

Regrettably, Basel II's three-pillared framework of risk-based capital requirements, supervisors' review of bank activities, and market discipline of banks, ignores a role for risk-based deposit insurance.[7] As shown by Gordy (2003), Basel II's Internal Ratings Based (IRB)

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[5] Restrictions on bank activities could be considered an additional regulatory policy. However, risk-based capital requirements can incorporate a restricted activity by assigning it an infinite risk-weight.
[6] I am abstracting from informational problems that may preclude the implementation of fairly-priced deposit insurance, as in Chan, Greenbaum, and Thakor (1992).
[7] For example, there is no reference to deposit insurance in the 216 page Basel Committee on Bank Supervision Third Consultative Paper (2003).

approach formulates capital requirements that result in a large, well-diversified bank having a probability of solvency over a one-year horizon of approximately 99.9 %. This fixed solvency probability is logical when deposit insurance premiums are presumed to be insensitive to risk. But fixing a bank's solvency probability is the reason why capital requirements rise when default risk increases during recessions.

Kashyap and Stein (2003) model the social welfare implications of setting capital requirements and argue that, unlike Basel II, regulators should permit a decline in banks' probability of solvency during recessions as the shadow value of bank capital rises.[8] However, they do not consider how to resolve this policy's effect on deposit insurance losses. I emphasize that such a capital policy requires raising insurance premiums during recessions to avoid a deposit insurance subsidy. Moreover, integrating risk-based deposit insurance with this capital policy would be less procyclical than a Basel II-type policy and would permit bank behavior to more closely match that of unregulated firms. Empirical evidence finds that during recessions the equity to asset ratios of non-bank firms decline while the default risk premiums or "credit spreads" that they pay on their debt increase.[9] If bank regulation minimizes distortions by replicating private financial contracts, then, during recessions, banks' equity capital ratios should be permitted to decline while their deposit insurance premiums should increase.

A coordinated policy of risk-based deposit insurance and capital requirements is not only less procyclical than a Basel II policy, but it can reduce the procyclical impact of "reserve targeting" deposit insurance systems. Such systems, which set insurance premiums to target the level of insurance fund reserves, are employed in a number of countries. This includes the United States where reducing the cyclicality of premiums motivates recent proposals for deposit

[8] Gordy and Howells (2004) evaluate different ways of implementing this policy whereby capital requirements are set such that banks' solvency probability declines (rises) during recessions (expansions).
[9] For example, Korajczyk and Levy (2003) find that unconstrained firms' leverage ratios increase during business cycle downturns when issuing equity is unattractive. Collin-Dufresne, Goldstein, and Martin (2001) and Campbell and Taksler (2003) find that firms' credit spreads increase during times of both firm-specific and market-wide uncertainty. A firm's credit spread also tends to increase as its leverage rises.

insurance reform. Current U.S. law requires the Federal Deposit Insurance Corporation (FDIC) to link commercial banks' insurance premiums to the level of reserves in the FDIC's Bank Insurance Fund (BIF).[10] When reserves exceed the Designated Reserve Ratio (DRR) of 1.25 % of insured bank deposits, all but the riskiest banks pay zero premiums for deposit insurance. Conversely, all banks could pay annual premiums up to 23 basis points per deposit when the DRR is below 1.25 %. Since BIF reserves are depleted by the deposit insurance claims of failed banks, business and bank failures during a recession would raise premiums for all banks. As argued in FDIC (2001, p.5), such a premium increase would harm the economy:

> "…banks are likely to be faced with very steep deposit insurance payments when earnings are already depressed. Such premiums would divert billions of dollars out of the banking system and raise the cost of gathering deposits at a time when credit already might be tight. This, in turn, could cause a further cutback in credit, resulting in a further slowdown of economic activity at precisely the wrong time in the business cycle."

Pennacchi (1999) used a sample of 68 large U.S. banks to estimate the cyclicality of insurance premiums under a reserve targeting policy. The results confirmed that, during recessions, reserve targeting premiums often can exceed the average of banks' fair, risk-based premiums. Also, evidence was found that banks respond to these higher premiums by reducing their deposits. Hence, this research supports the FDIC's concern that its reserve targeting policy has a procyclical impact on bank credit. A reserve targeting policy can compound the procyclicality of Basel II because excessively high premiums worsen banks' capital deficiencies, leading to greater shrinkage in banks' assets and deposits needed to meet capital requirements. But even without capital deficiencies, higher-than-fair insurance premiums raise banks' funding

[10] BIF reserves are the accumulated value of premiums previously paid by commercial banks less the value of FDIC losses from past bank failures. The FDIC also maintains a separate reserve fund for thrift institutions, known as the Savings Association Insurance Fund (SAIF). See Pennacchi (1999) for an analysis of setting insurance premiums to target FDIC reserves.

costs and can lead them to reject loans that would have a positive net present value if premiums were set fairly.

The FDIC (2001) proposes reforms that would permit it to set risk-based premiums independent of BIF reserves.[11] However, while divorcing premiums from BIF reserves eliminates one source of procyclicality, making premiums risk-based creates another. Similar to risk-based capital standards, risk-based deposit insurance premiums tend to rise during recessions as banks' financial conditions worsen. A contribution of this paper is to quantify the cyclicality of risk-based premiums for different deposit insurance contract designs. This complements the cyclicality estimates of risk-based capital standards provided by several recent studies, many of which are reviewed in Kashyap and Stein (2004). Importantly, I show that the cyclicality of premiums can be smoothed intertemporally by structuring a deposit insurance contract as a moving average of longer-term contracts.[12] The greater is the degree of smoothing, the higher is the average level of insurance premiums needed to compensate a government deposit insurer for its greater exposure to systematic risk.

The rest of this paper is organized as follows. The next section examines how regulation can reduce a bank's desire to lend when it is capital-deficient and provides a novel argument for why optimal bank regulation should integrate risk-based insurance premiums with risk-based capital standards. It shows that employing risk-based deposit insurance premiums reduces the procyclicality of bank credit relative to a Basel II-type pure risk-based capital policy. Section 3 discusses how risk-based deposit insurance can be structured to further mitigate procyclicality. It is done by structuring deposit insurance as a moving average of contracts. Section 4 presents estimates of moving average insurance premiums for 42 banks based on data over the period 1987 to 1996. It shows that lengthening the average maturity of the insurance contracts reduces

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[11] If maintaining an insurance fund with a stable DRR is desired, it could be done with a separate rebate/assessment scheme that would be independent of a bank's current risk or deposit level. See Wilcox (2001) for an example of such a proposal.

the volatility of premiums, but also raises the average level of premiums. Conclusions are given in Section 5.

2. Reducing Procyclicality with Risk-Based Insurance Premiums

There has been extensive research on the supply of bank credit over the business cycle, and theories of procyclicality are not limited to regulation-based explanations.[13] For example, Rajan (1994) models an agency problem where bank managers are assumed to have short-term reputational concerns and can conceal problem loans by lending new money to insolvent borrowers. Because a manager's reputation suffers more when problem loans are revealed during an economic expansion than during a recession, managers lend excessively during expansions. Berger and Udell (2003) propose an "institutional memory hypothesis" where loan officers' abilities to avoid making problem loans deteriorate since their bank's last episode of significant loan losses. Procyclicality occurs because banks' credit standards decline as an economic recovery progresses, thereby worsening the next downturn. Thakor (2003) analyzes a model where bank loan commitments provide insurance against credit rationing. During economic downturns, a bank invokes the commitment's "materially adverse change" clause to refuse loans to uncreditworthy borrowers. However, to preserve its reputational capital, the bank honors its commitments to such borrowers during economic upturns, resulting in overlending.

These theories predict that managerial and reputational factors create procyclicality by generating an oversupply of bank credit during economic expansions. In contrast, bank regulation, which is the focus of my analysis, can have a further procyclical impact by reducing the supply of bank credit during recessions. This source of procyclicality relies on market imperfections that are assumed to raise the cost of a firm's external financing when its net worth declines during a recession. Because agency costs derived from information asymmetries tend to

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[12] My analysis assumes that capital requirements are also smoothed in a manner similar to Gordy and Howells (2004).
[13] See Berger and Udell (2002) for a summary of this literature.

increase as a firm's (or bank's) financial condition deteriorates, external finance, especially new shareholders' equity, becomes more expensive.[14] In turn, a higher cost of external financing depresses the firm's investment spending.

Credit supplied by banks may be particularly depressed during recessions. Unlike other firms, banks cannot hope to operate with deficient capital until business conditions improve. Regulators may pressure banks to improve their capital immediately.[15] To increase its capital ratio, a bank has few options. First, it could cut its dividend payments, but the resulting capital increase is only gradual and limited. Second, the bank could issue new shareholders' equity, though this is an unattractive choice if external finance is costly when capital is low. Third, the bank could raise its capital ratio by reducing both assets and deposits. If capital ratios are risk-based, this requires shrinkage of assets that bear positive risk-weights, including loans to bank-dependent borrowers, such as small businesses. Reducing the supply of loans to these most vulnerable of borrowers has been described as a "capital crunch."[16] Importantly, there is substantial empirical evidence that capital deficient banks choose this last option and contract their lending and deposit growth to raise their capital ratios.[17]

Under the risk-based capital policy envisioned by Basel II, a bank's minimum capital ratio would rise as the default risk of its loans increases during a recession. This is one way to control a government's exposure to deposit insurance losses and to avoid a safety net subsidy. However, there exists an alternative mechanism for achieving this objective: require the bank to

[14] Research on this topic includes Myers and Majluf (1984), Greenwald, Stiglitz and Weiss (1984), Bernanke and Gertler (1989), and Kiyotaki and Moore (1996).

[15] Peek and Rosengren (1995a) find that regulatory enforcement actions are especially effective in reducing lending at capital-deficient banks.

[16] In principle, banks could reduce their on-balance-sheet loans by selling or securitizing them. This may be possible for (syndicated) loans to large businesses, mortgages, and some consumer receivables. However, the heterogeneous nature of loans to smaller businesses along with their potential adverse selection and moral hazard problems make these types of loans difficult to sell without recourse. See Gorton and Pennacchi (1995). Therefore, banks facing capital pressures are likely to reduce their supply of credit to these bank-dependent borrowers.

[17] A partial list of research documenting this behavior is Bernanke and Lown (1991), Baer and McElravey (1994), Hancock, Laing, and Wilcox (1995), Peek and Rosengren (1995b), Chiuri, Ferri, and Majnoni (2002), and Campello (2002).

pay a higher deposit insurance premium as its risk of failure increases. A natural question is whether a higher insurance premium is better or worse than a higher capital ratio in terms of its impact on the bank's lending. Though the bank's assets and deposits decline when it raises its capital ratio, payment of a higher deposit insurance premium also reduces the bank's assets available for lending.

The relative procyclicality of risk-based capital standards versus risk-based deposit insurance can be analyzed as follows. Suppose that under a risk-based capital policy, all banks are charged the same deposit insurance premium that is a fixed proportion of each bank's deposits, call it h_f.[18] Then, given payment of this fixed rate, regulators set each bank's capital ratio so that the deposit insurer's net liability for each bank equals zero. In other words, each bank's risk-based capital ratio is "fair" in the sense that the bank receives a net government subsidy of zero.[19] Next, compare this pure risk-based capital policy to a pure risk-based deposit insurance policy where each bank pays a different fair deposit insurance premium and is not required to adjust its capital ratio to any particular level. A bank's risk-based insurance premium per dollar deposit, call it h_r, is set fairly so that, as in the case of a risk-based capital policy, the government insurer has a net liability equal to zero.

Now, suppose that a bank's risk of failure unexpectedly increases due to a decline in its asset value and/or an increase in its asset risk, a typical situation at the start of a business cycle downturn. Specifically, assume that under a risk-based capital policy, if the bank pays its fixed premium at rate h_f but does not make any other adjustments, its resulting capital ratio would be lower than its fair one.[20] Given a bank in this situation, calculate the bank's resulting asset value after it pays its fixed insurance premium and it reduces its assets and deposits to a degree

[18] For simplicity, banks are assumed to have no non-deposit liabilities, though this assumption is not central to the analysis.
[19] This is the generally accepted definition of a fair capital standard. For example, see Flannery (1991).
[20] In other words, the bank's solvency probability would be lower than required, and the fixed insurance premium paid by the bank would be insufficient to cover the present value of its deposit insurance losses. For the case of Basel II, this bank's solvency probability would be less than 99.9%.

sufficient to give it a new capital ratio that is fair. Denote this resulting asset value as A^C_{t+}.

Lastly, start with the same bank and, under a risk-based insurance policy, require that it pay a fair deposit insurance premium at rate $h_r > h_f$ but not reduce its deposits. Let this bank's resulting asset value be A^P_{t+}. The following proposition contrasts these two policies.

Proposition: *Consider a bank that would have a deficient (less than fair) capital ratio if it paid a fixed deposit insurance premium at rate h_f and did nothing else. Assume that the bank does not issue new shareholders' equity but achieves its higher fair capital ratio by reducing its deposits and assets. Let A^C_{t+} be this bank's resulting asset value that returns its deposit insurer's net liability to zero. Next suppose that the original capital-deficient bank paid a higher fair insurance rate $h_r > h_f$ in order to return its deposit insurer's net liability to zero, instead of raising its capital ratio by reducing deposits. Let this bank's asset value after paying its higher fair premium be A^P_{t+}. If a fair deposit insurance premium is a convex function of the bank's asset/liability ratio, then $A^P_{t+} > A^C_{t+}$. That is, a bank's assets decline less under a pure risk-based deposit insurance policy compared to a pure risk-based capital policy.*

Proof: See Appendix A.

As detailed in Appendix A, this proposition holds under general conditions. It relies only on a fair insurance premium being convex in the bank's asset/liability (or capital) ratio, a condition satisfied by the vast majority of (option-pricing) models that might be used to set fair premiums.

The proposition compares two policies that are polar extremes: a pure risk-based capital standard where deposit insurance rates are fixed, versus a pure risk-based deposit insurance program where no particular capital ratio is required. However, a policy that integrates these two extremes is clearly possible and, as discussed earlier, is likely to be preferred. Under a hybrid policy, a bank that would be capital deficient under a pure risk-based capital policy could be required to *partially* adjust its capital ratio toward a target standard and pay a higher fair insurance premium commensurate with the capital ratio it actually chooses. Such a policy would protect a government insurer from losses due to bank failure, yet it would be less pro-cyclical than the strict risk-based capital policy envisioned by Basel II.

Though the effect is muted, risk-based deposit insurance premiums still have a pro-cyclical impact. Importantly, however, policies for setting fair, risk-based deposit insurance premiums can be designed to have different degrees of procyclicality. This is the issue that is addressed in the next section.

3. Deposit Insurance Premiums for a Moving Average of Contracts

This section begins by discussing the motivation and basic structure of a risk-based deposit insurance policy that can smooth insurance premiums over the business cycle. Following this, I describe an insurance valuation model that will be used in section 4 to quantify the degree of premium smoothing for a sample of large, U.S. banks.

3.1 *Reducing the Cyclicality of Insurance Premiums*

The debt contracts of unregulated firms vary widely with respect to their maturities and re-pricing features. For example, a firm that issues primarily short-maturity debt that re-prices frequently pays a default risk premium (difference between its interest rate and an equivalent maturity default-free rate) that reacts quickly to changes in the firm's financial condition. In contrast, a firm financed primarily by long-maturity debt pays a default risk premium that reacts only gradually to changes in the firm's default risk. In a like manner, fair deposit insurance contracts can be designed to have insurance premiums react either rapidly or gradually to changes in a bank's financial condition. The slower that premiums react to a bank's risk, the lower is the premiums' volatility over the business cycle and the less is their procyclical impact.

Previous papers have suggested methods for reducing cyclical movements in deposit insurance premiums. Konstas (1992) and Shaffer (1997) advocate similar systems in which insurance premiums are set to a long-term moving average of past FDIC insurance claims from bank failures. The method that I propose is related to these, but with a significant difference. Rather than being a moving average of past FDIC losses, the moving average is forward looking: insurance rates are set fairly, equal to a moving average of the value of the FDIC's exposure to future losses.

Deposit insurance rates can be set fairly, be relatively stable, and yet be subject to frequent updating if the insurance is structured as a combination of several long-term contracts whose contract intervals partially overlap. To illustrate, suppose that a deposit insurer updates a bank's insurance premium once per year, and the initial terms of the overlapping insurance contracts are n years, where n is an integer ≥ 1. Then a bank's deposit insurance can be decomposed into n insurance contracts, where each lasts n years and covers $\frac{1}{n}^{\text{th}}$ of the bank's total insured deposits. If the current date is denoted as 0 and dates are measured in years, then the most recently updated contract covers the interval from date 0 to date n. The contract updated one year ago covers the interval from date –1 to date n-1, while the contract updated two years ago covers the interval from date –2 to date n-2. Thus, the oldest contract, updated n-1 years ago, covers the interval from date n-1 to date 1. Figure 1 illustrates this overlapping of contracts for the case of $n = 5$.

PLACE FIGURE 1 ABOUT HERE

If each of the n contracts assigns an initially fair annual premium to its $\frac{1}{n}^{\text{th}}$ share of the bank's deposits, the overall set of contracts provides no subsidy. At a given date, the bank's total insurance premium per deposit is the average of the n different rates. Importantly, as n increases, the bank's total premium becomes less volatile, since new information affects only a $\frac{1}{n}^{\text{th}}$ share of deposits the next time the premium is revised. However, as time passes, more of the individual contracts mature and are re-priced, so that the total premium eventually reflects changes in the bank's financial condition. Still, this "moving average" of overlapping contracts intertemporally smoothes the premium relative to a short-term contract that fully re-prices annually.[21]

A bank insured by this moving average contract is analogous to a firm with uninsured debt comprised of *n* different bonds, each bond having an initial maturity of *n* years but having been issued at different, consecutive prior annual dates. Each year, one of the firm's bonds matures and is rolled over into a new *n*-year maturity bond. If investors price each new bond fairly based on the firm's financial risk, then the firm's total interest expense, including the premium it pays for default risk, is a moving average of interest expenses from its *n* different bonds. Of course, the speed at which a firm's or bank's cost of debt responds to its financial risk can affect risk-taking incentives. Longer maturities for bond or deposit insurance contracts provide greater intertemporal insurance at the cost of increased moral hazard. As with any insurance, this trade-off probably is unavoidable. An implication is that bank supervisors need to be more vigilant as a bank increases its contract maturities.

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[21] The vast majority of empirical studies that value deposit insurance assume that the insurance fully re-prices at each date that regulators audit a bank, usually assumed to be at annual intervals. Examples include Marcus and Shaked (1984), Ronn and Verma (1986), and Giammarino, Schwartz, and Zechner (1989). However, there is no reason why the assumption of full re-pricing is required.

3.2 *Valuing Deposit Insurance for a Moving Average of Contracts*

To calculate actual insurance premiums for banks under this moving average framework, a model for valuing each overlapping contract is needed.[22] My model extends Cooperstein, Pennacchi, and Redburn (1995) and Pennacchi (1999) to allow for stochastic interest rates and an exogenous FDIC loss rate following a bank's failure. In addition, the model assumes a bank partially adjusts its capital ratio toward a target level, consistent with bank behavior envisioned by a hybrid policy that integrates risk-based capital standards with deposit insurance. The following five assumptions are made.

A.1 ***Default-free bond price process***: *Define $P_t(t)$ as the date t price of a default-free zero-coupon bond that pays* \$1 *at date $t+t$. The value of this bond follows the process*

$$dP_t(t)/P_t(t) = a_p(t,t)dt + s_p(t)dq \tag{1}$$

where dq is a Brownian motion process, $a_p(t,t)$ is the bond's expected rate of return, and $s_p(t)$ is the standard deviation of the bond's rate of return. $s_p(t)$ is an increasing function of the bond's time until maturity, t, and $\lim_{t \downarrow 0} s_p(t) = 0$.

The bond price dynamics in (1) are consistent with Vasicek (1977), and from this the instantaneous maturity (short-term) default-free interest rate is defined as $r_t \equiv \lim_{t \downarrow 0} a_p(t,t)$.[23]

A.2 ***Bank asset return generating process***: *Let A_t be the date t market value of a bank's assets. The rate of return on these assets satisfies*

$$dA_t / A_t = a_a(t)dt + s_a dz \tag{2}$$

[22] FDIC (2000, 2001) discusses a variety of risk-based pricing methods. In addition, the Basel II methodology for estimating risk-based capital standards (see Basel Committee on Banking Supervision, 2003) could be used to estimate risk-based insurance premiums.
[23] In equilibrium term structure models, $a_p(t,t) = r_t + l\, s_p(t)$ where l is the market price of risk associated with dq. For example, the Vasicek (1977) model assumes $dr = k(q-r)dt - s\,dq$ and results in bond prices equal to $P_t(t)=A(t)e^{-B(t)r}$ where $A(t) \equiv \exp\{(B(t)-t)[q+ l\,s/k - ½(s/k)^2-(sB(t))^2/(4k)]\}$ and $B(t) \equiv (1-e^{-kt})/ k$.

dz is another Brownian motion such that $dzdq = \rho dt$. σ_a*, the standard deviation of the rate of return on bank assets*, *is assumed to be constant over each yearly interval.*[24]

A.3 ***Liability return generating process***: *A bank's total non-ownership liabilities are assumed to earn a market rate of return satisfying*

$$dD_t / D_t = \alpha_d(t)dt + \sigma_d dq \tag{3}$$

Since a bank's liabilities are a portfolio of fixed-income securities, their value depends on the same source of risk as other bond-like instruments. Hence, the bond and bank liability processes of (1) and (3) are both driven by dq. Following Pennacchi (1987a,b), the sensitivity of a given bank's total liabilities to changes in interest rates, σ_d, is assumed to be constant, the implication being that the bank maintains a constant duration for its liabilities.[25]

Equations (2) and (3) determine the primary sources of uncertainty affecting the rate of return on bank assets and liabilities. Imperfect correlation between bank assets and liabilities, $|\rho| < 1$, reflects the exposure of bank assets to additional sources of risk, such as credit risk or risk from changes in the market value of off-balance sheet derivative positions.

A.4 ***Behavior of bank regulators***: *Denote a bank's asset/liability ratio as* $x_t \equiv A_t/D_t$. *The bank is audited at the end of each year and*, *if at that time* $x_t < \phi$, *it is closed.*[26] *When a bank of type b is*

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[24] σ_a could be allowed to change from year to year as a function of the bank's end-of-year asset/liability ratio. Our empirical work assumes it is constant.

[25] Consistent with A.1, σ_d is an increasing function of the duration of the bank's liabilities, and for the special case of a zero duration (all liabilities re-price instantaneously), $\sigma_d = 0$ and $\alpha_d(t) = r_t$.

[26] An annual auditing interval is chosen to roughly correspond with the Federal Deposit Insurance Corporation Improvement Act (FDICIA) requirement that full-scope, on-site examinations be held each year. An analysis of information benefits versus resource costs by Hirtle and Lopez (1999) finds that this annual examination frequency is reasonable. The parameter ϕ measures how quickly regulators act to close weak banks. For banks with significant uninsured liabilities, regulators may be forced to act when a decline in a bank's market value capital ratio leads to a substantial outflow of uninsured funds. FDICIA requires closure when a bank's book value capital ratio equals 2 %, a point when the bank's market value capital ratio, $x_t - 1$, is often much less. The question of whether an optimal value of ϕ should be fixed, or should depend on the state of the macro-economy is beyond the scope of this paper, though different models of closure are unlikely to change our qualitative results.

closed, the deposit insurer incurs an expense for resolving the failed bank that is assumed to equal a proportion f_b of the failed bank's liabilities. Thus, if the bank fails at date T, the insurer experiences a loss equal to

$$F_T = f_b D_T \tag{4}$$

Unlike previous Merton (1977)-type "structural" models which relate the FDIC's loss to the failed bank's assets and various classes of liabilities, (4) follows Longstaff and Schwartz (1995), Collin-Dufresne and Goldstein (2001), and recent research on deposit insurance pricing by Duffie, Jarrow, Purnanandam, and Yang (2003) by assuming the FDIC's loss rate for a particular type of bank is exogenous.[27] This simplification is motivated by the difficulty of specifying FDIC losses in terms of the assets, deposits, and other senior and junior liabilities of the failed bank. As with non-banking firms, absolute priority of liabilities often is violated when failure occurs because many uninsured liabilities can withdrawn or secured shortly before the bank is closed. The appropriate loss rate, f_b, can be estimated from the FDIC's loss experience for a bank of type *b*.[28]

A.5 *Other activities of banks*: *Immediately following regulators' audit of the bank at the end of each year, if the bank is allowed to remain in operation, then the following three discrete adjustments occur*: 1) *Liabilities grow discretely at the rate g_d*:

$$D_{t^+} = (1 + g_d) D_{t^-} \tag{5}$$

[27] In these papers, default occurs when a firm's assets decline to a specified threshold. Bondholders then recover (1-*w*) times the value of a default-free bond, where *w* is the exogenous loss rate. Exogenous losses given default also are assumed in "reduced-form" models which specify default as a Poisson process having a stochastic default intensity. An example is Duffie and Singleton (1999).

[28] A bank's type could depend on its proportions of insured deposits, uninsured domestic and foreign deposits, senior non-deposit liabilities, junior (subordinated) non-deposit liabilities, and other characteristics such as the bank's size and location. Shibut (2002) analyzes how FDIC loss rates relate to the characteristics of a bank's liabilities. Our empirical work specifies f_b based on the FDIC's historical loss rates for banks categorized by size. If future loss rates are similar to those of the past, our less complicated modeling may give reasonably accurate estimates of the FDIC's liability.

where D_{t-} denotes the value of the bank's liabilities just prior to their growth at date t while D_{t+} denotes the value of bank liabilities just after date t; 2) *A deposit insurance premium equal to* H_t D_{t+} *is paid*;[29] 3) *The bank adjusts its asset / liability ratio so as to move partially toward its target capital/asset ratio. Specifically, if $x_{t-} = A_{t-}/D_{t+}$ is the bank's asset/liability ratio just prior to the adjustment, x^* is the bank's target ratio, and $x_{t+} = A_{t+}/D_{t+}$ is the bank's asset/liability ratio following the adjustment, then the end-of-period asset/liability ratio satisfies*

$$x_{t^+} = x_{t^-} + k\left(x^* - x_{t^-}\right) \tag{6}$$

Equation (6) allows a bank's capital (or leverage) to partially adjust to a target level, and our empirical analysis in Section 4 permits each bank to have a unique asset/liability target, x^*. This is consistent with empirical evidence by Ashcraft (2001), Falkenheim and Pennacchi (2003), Flannery and Rangan (2002), and Shrieves and Dahl (1992) showing that banks' capital ratios mean revert to targets, and that banks with greater asset/liability risk tend to have higher target capital ratios. Also, equation (6) can be interpreted as the autoregressive smoothing of Basel II capital requirements suggested by Gordy and Howells (2004). In this case, x^* is the bank's capital ratio required by Basel II while x_{t+} is the bank's smoothed capital requirement. This capital process allows a bank to have less capital during recessions and gradually adjust back to its Basel II level.

Note that while equations (2) and (3) characterize the rates of return on the existing stocks of bank assets and liabilities, the value of assets and liabilities can change due to inflows and outflows. Specifically, dividend payments, equity issues and repurchases, payment of bank deposit insurance premiums, and net new deposit growth can change the quantity of a bank's assets and/or liabilities. For computational simplicity, these sources and uses of funds are assumed to take place at a single point in time and lead to the adjustments given in (5) and (6).

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[29] H_t is the premium as a proportion of total bank liabilities. The premium as a proportion of total domestic deposits would equal H_t times the ratio of the bank's total liabilities to domestic deposits. Note that H_tD_t is

In summary, the following events occur each year: i) The market values of bank assets and deposits change stochastically during the year following the return processes in equations (2) and (3); ii) Regulators audit the bank at the end of each year and determine whether to close it. If the bank is closed, the deposit insurer's payment to resolve the failure equals the expression in (4); iii) If regulators allow the bank to continue operations, then end-of-year liabilities grow discretely according to equation (5), a deposit insurance premium is paid, and bank assets change due to share purchases and/or dividend payments so as to adjust the bank's capital/asset ratio according to (6). Starting again at i), the events are repeated for the following year.

Given these assumptions, I now can determine an insurer's liability for guaranteeing the deposits of a particular bank for a period of n years. Following this, the annual premium that the bank needs to pay to cover this n-year liability is derived. Lastly, I solve for this bank's insurance premium when its insurance plan is a moving average of n overlapping contracts.

Define l_{0n} as the current value of the insurer's liability for the possible failure of the bank occurring at only date n, which currently is n years in the future. This liability, l_{0n}, is a contingent claim whose value depends on the bank's assets and liabilities, allowing us to apply standard no-arbitrage pricing theory. This is done by first considering a hypothetical bond mutual fund that invests in default-free bonds having the same duration as that of the bank's total liabilities. Let this fund's date t share price be B_t. Since the mutual fund's duration equals that of the bank's liabilities, its rate of return process is the same as that of D_t given in equation (3). Assuming, with no loss of generality, that $B_0 = D_0$, then the only difference between the values of B_t and D_t is that total liabilities, D_t, grow discretely at rate g_d at the end of each year when the bank is not closed. This implies that at some beginning-of-year date, t =1, 2, …, for which the bank is still in operation, $D_t = B_t(1+g_d)^{t-1}$.

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the actual premium paid by the bank, which may differ from the fair premium calculated below.

Next, let us normalize (deflate) the value of the insurer's liability by this bond fund's share price, B_t.[30] It can be shown that the absence of arbitrage opportunities in the original non-normalized price system implies an absence of arbitrage in this normalized one and, further, that a probability measure exists for which the normalized process, l_{tn}/B_t, is a martingale:

$$\frac{l_{0n}}{B_0} = E_0^Q\left[\frac{l_{nn}}{B_n}\right] \tag{7}$$

where E_0^Q denotes the date 0 expectation operator under the risk-neutral probability measure Q. Equation (7) can be simplified because assumption A.4 states that if the bank fails at date n, then the insurer's loss would equal f_bD_n. Otherwise, its loss at date n is zero. Failure at date n would occur if $x_t \geq f$ for $t = 1, \ldots, n$-1, but $x_n < f$.

Define p_{0n} as the date 0 probability under measure Q that this set of events occurs, namely, $x_t \geq f$ for $t = 0, 1, \ldots, n$-1, but $x_n < f$. Shortly, the method for computing p_{0n} will be discussed, but for now, I emphasize that p_{0n} differs from the true or "physical" probability of failure because p_{0n} adjusts for a risk premium. Given this definition, equation (7) can be written:

$$\begin{aligned}\frac{l_{0n}}{B_0} &= \frac{f_bD_n}{B_n}\,p_{0n} = f_b\,\frac{B_n\left(1+g_d\right)^{n-1}}{B_n}\,p_{0n} \\ &= f_b\left(1+g_d\right)^{n-1}p_{0n}\end{aligned} \tag{8}$$

Since $B_0 = D_0$, equation (8) implies

$$l_{0n} = f_b\left(1+g_d\right)^{n-1}D_0\,p_{0n} \tag{9}$$

Next, define L_{0n} as the value of an insurance contract that extends from the current date up until and including date n. Then the value of this n-period contract is simply the sum of the values of the single-date contracts.

$$L_{0n} = \sum_{i=1}^{n} l_{0i} = f_bD_0\sum_{i=1}^{n}\left(1+g_d\right)^{i-1}p_{0i} \tag{10}$$

[30] This normalization technique can be traced to Merton (1973) and Margrabe (1978). Lewis and

Consistent with assumption A.5, suppose that the bank is charged annual insurance premiums to cover this n-period contract. Conditional on the bank not having failed beforehand, it would pay a premium at date t equal to $h_{0n}D_t$, t=0, 1, …, n-1. The value of these contingent premium payments can be derived in a manner similar that of the insurer's liability. Defining v_{0t} as the value of the single premium that the bank promises to pay at date t, it equals

$$v_{0t} = h_{0n}\left(1+g_d\right)^t D_0 \prod_{i=0}^{t}\left(1-p_{0i}\right) \tag{11}$$

where, assuming the bank is currently in operation, p_{00} = 0. Hence, the value of the sum of the annual promised premiums from dates 0 to n-1 is given by

$$V_{0n} = \sum_{t=0}^{n-1} v_{0t} = h_{0n} D_0 \sum_{t=0}^{n-1}\left(1+g_d\right)^t \prod_{i=0}^{t}\left(1-p_{0i}\right) \tag{12}$$

To determine the fair annual insurance premium that would set the insurer's net liability to zero for this n-year contract, I equate the value of the insurer's gross liability, L_{0n}, in equation (10) to the value of premium revenue, V_{0n}, in equation (12) and solve for h_{0n} to obtain

$$h_{0n} = f_b \frac{\sum_{i=1}^{n}\left(1+g_d\right)^{i-1} p_{0i}}{\sum_{t=0}^{n-1}\left(1+g_d\right)^t \prod_{i=0}^{t}\left(1-p_{0i}\right)} \tag{13}$$

Finally, the total premium for an n-year moving average insurance contract, that is, a contract composed of n overlapping contracts, each covering $\frac{1}{n}^{\text{th}}$ of losses, can be calculated. Denoting this premium as H_{0n}, it equals

$$H_{0n} = \frac{1}{n}\sum_{k=0}^{n-1} h_{(0-k)(n-k)} \tag{14}$$

To complete this derivation of a moving average insurance premium, a bank's risk-neutral failure probabilities, p_{0i}, i = 1, …, n, need to be specified. As a prelude, I discuss how the bank's physical probabilities of failure can be computed. While the risk-neutral probabilities are

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Pennacchi (1999) perform a similar normalization when valuing guarantees of pension benefits.

required for valuing the insurer's liability, the physical probabilities also may be useful. They can help calibrate the model's closure point, f, to make the model's implied frequency of bank failures match an historical failure rate.[31] Also, if one substitutes the physical probabilities for the risk-neutral probabilities in equations (13) and (14), the resulting insurance rates equal the expected loss of the deposit insurer discounted at a riskless rate. While such rates allow the government insurer to "break-even" on average, they fail to incorporate a premium for the systematic risk to which taxpayers are exposed.[32] Failure to include such a risk premium in insurance rates also would create financial system distortions and regulatory arbitrage because banks' cost of financing would differ from that of similar non-bank financial institutions, such as finance companies and investment banks.

A bank's failure probabilities are determined by the joint distribution of its end-of-year asset liability ratios, x_1, x_2, …, x_{n-1}, and x_n, which are generated by the processes (2), (3), and (6). Except for times when x_t changes discretely according to (6), Itô's lemma implies that $x_t \equiv A_t/D_t$ follows the process

$$\begin{aligned} dx/x &= \left(a_a - a_d + s_d^2 - s_{ad}\right)dt + s_a dz - s_d dq \\ &= a_x dt + s_x dw \end{aligned} \qquad (15)$$

where $s_{ad} \equiv r s_a s_d$, $a_x \equiv a_a - a_d + s_d^2 - s_{ad}$, $s_x^2 \equiv s_a^2 + s_d^2 - 2s_{ad}$, and dw is a standard Brownian motion process equal to $(s_a dz - s_d dq)/s_x$. Note from equation (15) that if the bank's liabilities are of short duration, then $s_d \approx 0$, $s_{ad} \approx 0$, and $a_d \approx r_t$. In this case, the expected rate of change in the bank's asset-liability ratio, a_x, equals the risk-premium on bank assets, $a_a(t)$-r_t.

[31] Interestingly, Huang and Huang (2003) find that when different credit risk models are calibrated to match historical bond default rates, the various models give surprisingly similar estimates of credit spreads. This suggests that calibrating an insurance pricing model to historical bank failure rates would lead to estimates of fair premiums that would be insensitive to the particular model's assumptions. Falkenheim and Pennacchi (2003) use the current article's model to estimate the physical probabilities of default for over 6,500 banks. When f =1, the average failure probability of these banks is close to historical failure rates.

[32] Bazelon and Smetters (1999) discuss the distortions that arise when government projects are discounted by a rate that fails to account for systematic risk.

Given estimates for a_a, a_d, s_a, s_d, and s_{ad}, equations (15) and (6) can be used to calculate the bank's actual probability of failure for each future date. If a model such as Vasicek (1977) is assumed, then a_x and s_x are constants and beginning-to-end-of-year changes in x_t are lognormally distributed. Starting from an initial asset-liability ratio, x_0, a random number generator can be used to calculate an end-of-year value, x_1, and, if $x_1 \geq f$, it would then change according to (6) and another lognormal random number would be used to generate a value for the end of the next year, x_2. This procedure would be repeated for all future years as long as $x_t \geq f$. If $x_t < f$ at some future year t, a failure would be recorded and the sequence would end. By starting from the same x_0 and simulating another path $x_1, x_2, \ldots, x_t, \ldots$ multiple times, the proportion of these sequences for which failure occurs at a particular year, t, can be calculated. For a sufficiently large number of sequences, this proportion becomes an accurate measure of the true probability of failure at year t.

Calculating a bank's risk-neutral probability of failure, that is, the probability under measure Q, is similar, but with one important difference. The process used to simulate future asset-liability ratios, x_t, is given by equation (15) except with $a_x = 0$, rather than $a_x = a_a - a_d + s_d^2 - s_{ad}$. Beginning-to-end-of-year changes in x_t continue to be lognormally distributed, but the expected rate of change is now zero rather than equal to the risk premium on bank assets relative to liabilities, $a_a - a_d + s_d^2 - s_{ad}$.[33] Assuming that $a_a - a_d + s_d^2 - s_{ad} > 0$, the simulated risk-neutral distributions for $x_1, x_2, \ldots, x_n$ will have greater probability mass in smaller values of the x_t's relative to the simulated physical distributions for $x_1, x_2, \ldots, x_n$. Hence, the risk-neutral probability of avoiding failure (survival probability) over any given horizon, $\prod_{i=1}^{n}\left(1 - p_{0i}\right)$, is less than the corresponding physical probability.

[33] Therefore, calculating the probability of failure under the risk-neutral Q measure does not require an estimate of the relative risk premium. Compared to calculating physical failure probabilities, less information and/or assumptions are needed.

4. Empirical Examples of Premiums under a Moving Average of Contracts

This section illustrates the dynamics of fair insurance premiums under a moving average of contracts by estimating these premiums for a sample of banking institutions. It quantifies the degree to which premium cyclicality can be reduced by lengthening the maturities of moving average contracts. It also demonstrates that the average risk premium paid for deposit insurance increases with contract maturities.

4.1 *Data and Parameter Estimation*

The data consist of 42 commercial banks and bank holding companies that had publicly-traded shareholders' equity and that are listed continuously on both CRSP and Compustat databases over the 10 year period, January 1987 through December 1996.[34] Summary statistics for these banks are in Table 1. Column one of the table shows that the banks are relatively large in size, with the mean and median of year-end 1996 total liabilities of \$34.1 billion and \$12.1 billion, respectively.[35] The second column gives the proportion of 1996 total liabilities that are in the form of domestic deposits.[36]

PLACE TABLE 1 ABOUT HERE

An empirical technique similar to Marcus and Shaked (1984) was used to calculate each bank's market value of assets to liabilities, x_t, for every month during the sample period and each bank's standard deviation of its assets to liabilities ratio, s_x. This was done using data on the market value and standard deviation of each bank's shareholders' equity, as well as the covariance of its equity's returns with changes in Treasury security rates. The procedure is

[34] Estimates of insurance premiums for privately-held banks can be obtained using the method of Falkenheim and Pennacchi (2003). They show how accounting and supervisory data can be used to find a private bank's implied market values of x_t and s_x and, in turn, its failure probabilities and fair premium.
[35] Total liabilities include all non-ownership liabilities, such as deposits and subordinated debt, but exclude preferred and common stock.

outlined in Appendix B. Table 1 summarizes the results, with column 3 giving the average monthly value of each bank's net worth to liability ratio, $x_t - 1$, and with column 4 giving each bank's estimated value of s_x.

The estimated net worth or capital, $x_t - 1$, for these banks varied substantially over the 1987 to 1996 period, a time when the commercial banking industry experienced an increasing number of failures followed by a strong recovery. The mean and median estimated capital to total liabilities ratios for the 42 banks over this 10-year period are 11.81 % and 11.32 %, respectively. The mean and median volatilities (annual standard deviations) of changes in capital across the 42 banks are 3.14 % and 3.13 %, respectively. The correlation between these banks' average capital ratios and their capital volatilities is 0.33. This positive correlation could reflect banks with riskier capital choosing higher capital because of Basel I risk-based standards and/or market discipline.[37]

These monthly estimates of the 42 banks' market values of capital were used to analyze the extent of mean reversion in capital ratios, that is, how quickly banks adjusted their capital ratios to a "target." Consistent with equation (6), a time series – cross-section autoregressive process of capital ratios was estimated (42 banks times 120 months = 5040 observations). Because banks with more volatile portfolios tend to maintain higher capital, when performing this regression each individual bank's target capital ratio was set equal to its sample average over the 10-year period. The resulting estimate for the mean reversion parameter k is 0.1766 and is statistically significant at the 99 % confidence level. This implies that if a bank's beginning-of-year capital ratio deviates from its target, then by year-end it is expected to revert 17.66 % back to its target. This mean reversion parameter, along with each bank's target capital ratio, then were used to simulate the capital processes required for computing insurance premiums.

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[36] Our insurance premium estimates are expressed as a proportion of a bank's total liabilities. Because current FDIC practice is to set premiums as a proportion of domestic deposits, this information is included.
[37] Evidence in Ashcraft (2001) and Flannery and Rangan (2003) suggests that, during this period, market discipline was the primary factor for higher capital ratios at banks with higher asset risk.

Using each bank's capital and volatility estimates at the end of each year during 1987-1996, 1 to 5 year failure probabilities were calculated, where the i^{th} year failure probability is the probability that the bank's net worth is negative at the end of i years. Both risk-neutral and physical probabilities of default were estimated. Recall that risk-neutral probabilities are calculated by setting both the expected rate of return on bank assets and liabilities to the short-term, risk-free interest rate. In contrast, the physical probabilities assume that the expected rate of return on bank assets exceeds that of liabilities by 0.985 % each year. This bank asset risk premium of 98.5 basis points was derived from the market returns on bank stocks, relative to the 30-day Treasury bill rate, over the period 1926 to 1996.[38]

In addition to computing failure probabilities for the 1987 to 1996 period, each bank's 1 to 5 year steady state failure probabilities were calculated. This was done by simulating for each bank a 1,000 year time-series of its asset/liability ratio (one plus its capital ratio), x_t. The simulation assumes that a bank's initial capital equals its individual target level, x^*, and then evolves randomly according to the processes given in (15) and (6).[39] Then, just as was done previously for the 10-year period, 1987 to 1996, 1 to 5 year risk-neutral and physical failure probabilities are calculated for each year during the 1,000-year simulation period.

4.2 *Results*

Table 2 summarizes the results from calculating failure probabilities based on the 1987 to 1996 period as well as for the 1,000-year (steady state) period. The table gives the mean and median failure probabilities across both banks and time. As expected, one sees that the risk-neutral probabilities are always larger than the corresponding physical ones since the capital ratio simulations that derive risk-neutral estimates correctly leave out a bank's asset risk-premium from their drift, as this premium compensates the insurer for exposure to systematic risk. Table 2

[38] See Pennacchi (1999 p.161) for details.
[39] The simulation generates a 1,000-year time-series for each of the 42 banks. Each bank's value of x^* and s_x are those estimated from the 1987 to 1996 period. Each bank's risk premium on bank assets is assumed to be 98.5 basis points.

also gives an indication of a skewed distribution, since the mean failure probabilities are much higher than the median ones. Further, the 1987 to 1996 decade was a relatively risky period, as the failure probabilities during this time are generally higher than for the steady state.

PLACE TABLE 2 ABOUT HERE

Figure 2 shows the risk-neutral first, third, and fifth year failure probabilities for two individual banks: one whose average first year failure probability ranked it at the median of all banks and one whose average first year failure probability ranked it at the 75th percentile. These banks are representative of the sample average in that their failure probabilities peaked at the beginning of 1991 and then declined during the latter half of the period. The figures also make clear that failure probabilities change more slowly for years farther into the future.

PLACE FIGURE 2 ABOUT HERE

The next step is to calculate fair and expected value insurance premiums using these failure probabilities and the formulas in equations (3) and (4) above. To do so, one needs to specify a bank's expected growth in liabilities in excess of the risk-free rate, g_d, and the FDIC's loss per bank liability should the bank fail, f_b. My calculations assume that each bank's expected liability growth equals the risk-free rate, that is, $g_d = 0$.[40] The FDIC's loss rate is assumed to depend on a bank's size. As reported in Table 3 of Oshinsky (1999), the FDIC's average loss rate

[40] This is slightly higher than the actual growth in aggregate bank liabilities over the sample period. From 1987-1996, total bank liabilities grew by 4.2 % while the return on three-month Treasury bills was 5.5 %. For simplicity, deposit growth rates are assumed to be constant. However, the model can be modified to allow deposit growth to vary as a function of the end-of-period capital ratio, as might occur if capital deficient banks shrink their deposits to partially raise their capital ratios back to target. Accordingly, the overlapping insurance contracts can be modified to cover different proportions (rather than each cover $1/n^{th}$) of total deposits. As each new n-year insurance contract replaces a maturing one, the incremental amount of deposits would be covered by the new n-year contract. Under such a rule, new deposits are insured at a rate reflecting the bank's current risk, thereby reducing moral hazard incentives.

for failures of top 50 banks during the period 1934-1997 was 3.2 % of failed bank assets, while its average loss rate for failures of banks ranked 51-100 in size was 6.6 %. Thus, I assumed that if a bank holding company had 1996 total liabilities exceeding \$15 billion, which placed it among the top 50 for that year, then the FDIC would experience a loss equal to f_b = 3.2 % of the bank's total liabilities at the time of failure. For all other bank holding companies in the sample, the FDIC's loss was assumed to equal 6.6 % of a bank's liabilities at the time of failure.

Table 3 gives the (simple) average fair and expected value insurance premiums for all banks over the 1987 to 1996 period and during the steady state for moving average contracts having n = 1 to 5 years. It shows that the average expected value premiums, which equal the FDIC's expected losses for the overlapping contracts, are over twice as high during the 1987-1996 period as during a steady state. Because the expected value premiums are calculated using physical default probabilities, there is a slight decline in the premium size as the number of overlapping contracts, n, increases. This is due to the effect of the bank asset risk-premium (98.5 basis points), which gives bank capital an upward drift and tends to reduce the likelihood of failure over the longer-term contracts.[41]

PLACE TABLE 3 ABOUT HERE

In contrast, one sees that the average fair premiums are higher than their expected value counterparts and rise as n increases. This is what asset pricing theory predicts. The fair premiums use the previously computed (higher) risk-neutral probabilities of failure, which adjust for the insurer's (taxpayers') exposure to systematic risk. Interestingly, the size of the deposit insurance risk-premium, which is approximately the difference between the fair premium and its corresponding expected value premium, increases with n. For the 1987-1996 period, the

[41] This implies that, on average, capital will be above its current level in the future. While the bank will tend to adjust capital downward if it is above target, the adjustment is only partial.

difference is 4.2 cents per $100 of liabilities when *n* = 1 and 8.9 cents per $100 of liabilities when *n* = 5. For the steady state, this premium equals 1.4 cents when *n* = 1 and 3.5 cents when *n* = 5.

The intuition for why the fair insurance risk-premium rises with the number and length of the overlapping contracts, *n*, can be developed by comparing the volatility of fair and expected value premiums. For contracts *n* = 1 to 5, the annual standard deviations of each bank's fair and expected value insurance premiums were computed for 1987-1996 and for a steady state. Table 4 shows the averages across the 42 banks of these standard deviations.

PLACE TABLE 4 ABOUT HERE

For both the fair and expected value premiums, the annual standard deviations decline significantly as *n* increases. This is the smoothing effect of a longer moving average. But while an increase in *n* reduces the variability of premiums paid by banks, the difference between premiums received and losses paid out by the FDIC becomes more volatile. In other words, the variance of the net revenue received by the FDIC for providing insurance (premiums minus losses) increases with *n*. Under a fair premium structure, the FDIC (taxpayers) must be compensated for this additional risk, and that is why the size of the risk premium increases as *n* becomes larger.

The previous tables reported averages across the 42 banks. Next, let us examine the premiums for individual banks. Table 5 reports the average 1987-1996 fair and expected value premiums for each of the 42 banks. Banks are ranked by the size of their average one-year (*n* = 1) fair premium. The distribution is skewed, with a few high-risk banks paying substantial premiums. However, it is clear that fair premiums are always at least as high as expected value premiums for any given bank and contract length. Figure 3 graphs the fair 1-, 3-, and 5-year contract premiums for the median bank, Marshall & Ilsley, and the 75th percentile bank, First Chicago NBD, during the period 1987-1996. It illustrates how the longer contract lengths provide significant intertemporal smoothing of premiums. For example, First Chicago NBD's fair premium for a one-year contract spikes to 92 basis points in 1991. In contrast, its fair premium for a five-year contract would have been 16 basis points in 1991 and would have reached a maximum of slightly less than 20 basis points in 1993.

PLACE TABLE 5 ABOUT HERE

PLACE FIGURE 3 ABOUT HERE

Table 6 reports statistics similar to Table 5's, but for the steady state. Again, the banks are ranked by the size of their average one-year fair premiums. In general, the steady state premiums are lower than those for the 1987-1996 period, but skewness still is apparent. Further, those banks that were relatively risky during 1987 to 1996 continue to be relatively risky based on their steady state premiums. It is also noteworthy that, as in the Table 3 averages, each bank's average expected value premiums generally decline with the length of its overlapping contract, n. However, also consistent with Table 3's averages, each bank's average fair premiums increase with the contract length.

PLACE TABLE 6 ABOUT HERE

The last table, Table 7, reports each bank's standard deviations of fair premiums computed over the steady state. Banks are ordered from lowest to highest in terms of the standard deviation of their one-year (n = 1) fair premium. Not surprisingly, banks that pay high premiums, on average, also have high standard deviations of premiums. However, with only a few minor exceptions, a bank's standard deviation of premiums declines monotonically with the length of the overlapping contract, n. As in Figure 3, this verifies that the moving average approach acts to reduce the cyclicality of premiums, especially for banks having moderate to high risk. It is these relatively risky banks that are most likely to suffer the procyclical effects of risk-based capital regulation, and so they would benefit the most from a fair, moving average deposit insurance plan.

PLACE TABLE 7 ABOUT HERE

5. Conclusion

The New Basel Accord has raised concerns regarding capital regulation's potential harm during business cycle downturns. Because agency costs of issuing new equity are high when financial conditions deteriorate, banks tend to shrink their risk-sensitive assets in response to higher required capital ratios, a reaction that could exacerbate a downturn by cutting off credit to bank dependent borrowers. There is not, however, an inevitable tradeoff between sound banking regulation and macroeconomic stability. The procyclical impact of risk-based capital requirements can be alleviated by incorporating risk-based deposit insurance.

This article showed that setting fair deposit insurance premiums is less procyclical than setting fair capital standards. Hence, procyclicality can be reduced if regulation allows increased bank risk to be reflected in higher deposit insurance premiums, not just higher capital requirements. Such regulation is consistent with the observed behavior of private, non-bank debt contracts in that credit spreads tend to rise during business cycle downturns. In addition, just as unregulated firms structure their debt in a variety of ways, deposit insurance can be designed in different forms. It was demonstrated that if fair deposit insurance is structured as a moving average of longer-term contracts, the cyclical effects of risk-based premiums can be reduced further.

The paper's empirical analysis confirmed that a moving average insurance plan can intertemporally smooth a bank's fair insurance premium to a substantial degree, thereby insuring the bank against paying high rates during times of financial distress. However, this intertemporal insurance comes at a cost to the bank. The fair risk premium needed to compensate taxpayers for their exposure to systematic risk is higher the longer is the average maturity of the insurance contract. Essentially, more stable deposit insurance premiums result in more volatile net revenues for the FDIC (and taxpayers): premiums will not rapidly rise to cover higher losses from bank failures during financial crises. The result is that under a stable system of premiums, more taxes need to be raised to cover FDIC losses during downturns in the banking industry. The undesirability of raising taxes during a recession is what results in a higher required risk premium.

In principle, just as unregulated firms choose the maturity structure of their debt, an individual bank could choose the length of its moving average insurance contract, trading-off a higher average fair insurance premium for greater rate stability. Empirical evidence finds that firms with longer maturity assets tend to issue long-term debt, suggesting that a bank with longer maturity loans might wish to match them with a longer insurance contract.[42] Other evidence finds that firms choose short-term debt prior to announcing positive earnings surprises, suggesting that a bank with improving prospects may prefer a shorter insurance contract in the hopes lengthening it after its good information is revealed. Such a choice might lead to counter-cyclical contract lengths, as banks select shorter contracts during business cycle troughs and longer ones at business cycle peaks. Recognizing such strategies, bank regulators may wish to place an upper limit on a contract's maturity, particularly since a bank's incentive for moral hazard rises when insurance rates adjust too slowly to changes in risk.

[42] Barclay and Smith (1995), Guedes and Opler (1996), and Stohs and Mauer (1996) analyze the factors that affect a corporation's choice of debt maturity.

Appendix A

The following is a proof of the proposition that a bank with an initial capital deficiency under a risk-based capital standard needs to reduce its assets more than if it operated under a risk-based deposit insurance system. The proof assumes a setting that takes seriously the empirical evidence that a bank's short-run response to a capital deficiency is to raise its capital ratio by reducing assets and non-ownership liabilities (deposits) rather than issuing new equity.

Under a pure risk-based capital standard similar to Basel II, a bank is assumed to pay an initial insurance premium that is a fixed proportion of its deposits, and its regulatory capital ratio is set to give its deposit insurer a zero net liability. Let h_f be the fixed premium per dollar of deposits, and let c^* be the bank's regulatory capital to liabilities ratio (after paying its insurance) that makes deposit insurance fairly valued at this fixed rate. The bank has initial assets of A_{t-} and initial deposits of D_{t-} where, for simplicity, the bank is assumed to have no other non-ownership liabilities. At these asset and deposit levels, if the bank paid its fixed deposit insurance premium and did nothing else, its resulting capital ratio would be

$$c = \frac{A_{t-} - D_{t-}\left(1 + h_f\right)}{D_{t-}} \tag{16}$$

It is assumed that $c < c^*$, as might occur at the start of a recession when the bank's asset value declines and/or its asset risk increases. From this initial capital deficiency, consider the reduction in assets and deposits that would restore the bank's capital ratio to the minimum standard, c^*. Let D_{t+} be the bank's deposits after this adjustment. To reach its minimum capital ratio after paying its fixed insurance premiums, D_{t+} must satisfy

$$c^* = \frac{A_{t-} - D_{t-} - h_f D_{t+}}{D_{t+}} \tag{17}$$

In the numerator of (17), note that A_{t-} - D_{t-}, is the bank's initial capital prior to paying its insurance, while $h_f D_{t+}$ is its insurance premium based on its new level of deposits. The bank's assets that are consistent with it meeting its required capital ratio are

$$A_{t+}^{C} = A_{t-} - h_f D_{t+} + D_{t+} - D_{t-} \tag{18}$$

Substituting for D_{t+} in (A.2) using (18), and then using (16) and (17) to eliminate D_{t-}, one can solve for the proportional decline in bank assets during the capital ratio adjustment process.

$$\frac{A_{t+}^{C}}{A_{t-}} = \frac{1+c^*}{1+c+h_f}\left(\frac{c+h_f}{c^*+h_f}\right) \tag{19}$$

This is the bank's reduction in assets under a pure risk-based capital standard.

Next, consider the polar case of a pure risk-based insurance system. As before, the bank does not raise additional equity but, unlike the case of a risk-based capital standard, the bank's insurance premium is raised to a new fair level. The bank's assets decline during this adjustment process because it is transferring more funds to the deposit insurer. Let h_r be the bank's fair risk-based premium per dollar of bank deposits, and let c_r be the bank's corresponding capital ratio. Given the same initial asset and deposit levels, A_{t-} and D_{t-}, but now assuming that the bank's premium, not its deposit level, changes, the value of c_r satisfies

$$c_r = \frac{A_{t-} - (1+h_r)D_{t-}}{D_{t-}} = c + h_f - h_r \tag{20}$$

and the final value of assets under a risk-based insurance system is simply

$$A_{t+}^{P} = A_{t-} - h_r D_{t-} \tag{21}$$

Therefore,

$$\frac{A_{t+}^{P}}{A_{t-}} = \frac{A_{t-} - h_r D_{t-}}{A_{t-}} \tag{22}$$

Substituting in for D_{t-}/A_{t-} using (16), equation (22) can be written as

$$\frac{A_{t+}^{P}}{A_{t-}} = \frac{1+c+h_f-h_r}{1+c+h_f} \tag{23}$$

Comparing (23) with (19), we obtain

$$\frac{A_{t+}^P}{A_{t+}^C} = \left(\frac{1+c+h_f-h_r}{c+h_f}\right)\left(\frac{c^*+h_f}{1+c^*}\right) = \left(\frac{1+c_r}{c_r+h_r}\right)\left(\frac{c^*+h_f}{1+c^*}\right) \tag{24}$$

Note that h_r is the fair insurance premium for the asset/deposit ratio of $1+c_r$ while h_f is the fair insurance premium for the asset/deposit ratio of $1+c^*$. It is well known that deposit insurance is analogous to a put option on the bank's assets with the present value of the option's exercise price equal to the bank's deposits. If one normalizes by the value of deposits, then the fair deposit insurance premium per deposit is a put option on the bank's asset/deposit ratio with the its exercise price having a present value of unity. Letting $h = P(1+c,1)$ denote the fair insurance premium (put option) for asset/deposit ratio $1+c$ and exercise price 1, equation (24) becomes

$$\frac{A_{t+}^P}{A_{t+}^C} = \frac{\left(\dfrac{1+c_r}{c_r+P(1+c_r,1)}\right)}{\left(\dfrac{1+c^*}{c^*+P(1+c^*,1)}\right)} \tag{25}$$

Since $c_r < c^*$, A_{t+}^P / A_{t+}^C will be greater than one if $x/[x-1+P(x,1)]$ is a decreasing function of x, which is the case if $[1-P(x,1)]/x < \partial P(x,1)/\partial x$. Since $P(0,1) = 1$, the condition is satisfied if $P(x,1)$ is a strictly convex function of x. Figure 4 graphically illustrates this result. As shown in Merton (1973) Theorem 10, a sufficient condition for the option price to be a convex function of its underlying asset value is that the asset's rate of return distribution be independent of its level. Such a condition is satisfied for the vast majority of option pricing models (e.g., Black-Scholes).

PLACE FIGURE 4 HERE OR JUST EARLIER

Appendix B

This appendix describes how market value asset-liability ratios, x_t, and their volatility, s_x, are estimated for each of the 42 banks in our sample. The method is an extension of Marcus and

Shaked (1984) that incorporates interest rate risk. Note that to compute $s_x^2 \equiv s_a^2 + s_d^2 - 2r s_a s_d$, estimates of the parameters s_a, s_d, and r are required. First, the parameter s_d was estimated using the technique described in Appendix B of Pennacchi (1987b). This procedure analyzes changes in a bank's total interest expense to estimate the proportions of its liabilities that are of particular maturity classes. Specifically, it starts by estimating the effective proportions of liabilities that are of 3-, 6-, 12-, and 36-month maturities by analyzing how a bank's total interest expense varied with yields on 3-, 6-, 12-, and 36-month Treasury securities. From these estimated maturity or duration proportions, the standard deviation of the rate of return on total bank liabilities, s_d, is computed using the Vasicek (1977) model of the term structure of interest rates. This was done for each of the 42 banks using interest expense data from Call Reports over the period 1987 to 1996.

Given an estimate for s_d, the variable x_t and the parameters s_a and r can be estimated in a manner similar to Marcus and Shaked (1984) and Pennacchi (1987b) using observations of a bank's market value of shareholders' equity, its equity's return standard deviation, and the covariance between its equity's return and changes in market interest rates. Define S_t as the current market value of a bank's shareholders' equity, s_s as the standard deviation of its equity's return, and s_{sr} as the covariance between its equity's return and changes in the short-term interest rate, r_t. Also let $s_t \equiv S_t/D_t$ be the value of the bank's equity per dollar of bank liability. By matching empirical estimates of s_t, s_s, and s_{sr} to their theoretical values, the parameters x_t, s_a, and r are estimated. Approximating the value of bank equity as a one-year call option on the firm's assets leads to the equations[43]

[43] The implicit assumption of this approximation for equity is that only the first year cost of deposit insurance might be unfairly priced. In other words, the current value of equity reflects future insurance premiums that equal the cost of insurance for each year following the first. The approximation error in pricing bank equity is probably modest, and even smaller errors in valuing s_s and s_{sr} are likely. The reason is that for banks that are currently in strong financial condition, the value of deposit insurance, for both the current and future years, is likely to be small or moderate. In contrast, for banks that are currently in weak

$$s_t = x_t N\left(d_{1,t}\right) - N\left(d_{2,t}\right) \tag{26}$$

$$s_s^2 = \left(N\left(d_{1,t}\right)\frac{x_t}{s_t} s_a \right)^2 + \left(\left[1 - N\left(d_{1,t}\right)\frac{x_t}{s_t} \right] s_d \right)^2 + 2N\left(d_{1t}\right)\left[1 - N\left(d_{1t}\right)\frac{x_t}{s_t} \right]\frac{x_t}{s_t} r s_a s_d \tag{27}$$

$$s_{sr} = -N\left(d_{1,t}\right)\frac{x_t}{s_t} r s_a s - \left[1 - N\left(d_{1,t}\right)\frac{x_t}{s_t} \right] s_d s \tag{28}$$

where $d_{1,t} = \left\{ \ln\left[x_t\right] + \frac{1}{2} s_x^2 \right\} / s_x$ and $d_{2,t} = d_{1,t} - s_x$.

The standard deviation of equity returns, s_s, and the covariance of equity returns with changes in the short-term (3-month Treasury bill) interest rate, s_{sr}, were estimated using weekly CRSP data for the year 1996. Also using Treasury bill data over the period 1968 to 1996, the standard deviation of the short-term interest rate was estimated to be s = 0.0224. From Bank Compustat, the year-end 1996 value of the market value of equity to total liabilities ratio, s_t, was obtained for each bank. Then inserting the values s_t, s_s, s_{sr}, s, and s_d into (26) to (28), these three non-linear equations were solved to obtain each bank's year-end 1996 value of x_t and its parameters s_a and r. From these estimates, each bank's value of $s_x^2 \equiv s_a^2 + s_d^2 - 2 r s_a s_d$ was determined. Lastly, CRSP and Compustat data were used to create a time series of monthly market value of equity to liability ratios, s_t, for each bank over the period 1987 through 1996. Inserting each bank's s_x and s_t into (26) then allowed us to solve for the bank's corresponding time series of monthly x_t values.

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financial condition, the value of deposit insurance for the first year is likely to represent the largest part of the total cost of insurance.

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Table 1

Summary Statistics for Sample Banks

Bank	1996 Liabilities ($ millions)	Proportion Domestic Deposits	Average Capital Ratio	Standard Deviation Capital Ratio
Sterling Bancorp, NY	784	0.729	0.0975	0.0301
Mid America Bancorp, KY	1,280	0.645	0.1418	0.0159
Westamerica Bankcorporation, CA	2,310	0.901	0.1123	0.0295
Hubco Inc, NJ	2,913	0.890	0.1183	0.0331
Cullen Frost Bankers Inc, TX	4,509	0.941	0.0697	0.0439
Trustmark Corp, MS	4,670	0.770	0.1029	0.0374
Firstmerit Corp, OH	4,704	0.894	0.1447	0.0352
Riggs National Corp, DC	4,709	0.780	0.0530	0.0337
Wilmington Trust Corp, DE	5,100	0.767	0.2206	0.0324
Deposit Guaranty Corp, MS	5,802	0.883	0.0959	0.0261
Mercantile Bankshares Corp, MD	5,807	0.920	0.1876	0.0393
Zions Bancorp, UT	5,978	0.742	0.1028	0.0401
First Virginia Banks Inc, VA	7,365	0.956	0.1549	0.0248
First Citizens Bancshares Inc, NC	7,440	0.935	0.0824	0.0264
Hibernia Corp, LA	8,370	0.926	0.1167	0.0392
First Commerce Corp New Orleans, LA	8,466	0.861	0.0940	0.0231
Commerce Bancshares Inc, MO	8,774	0.931	0.1108	0.0276
Star Banc Corp, OH	9,239	0.849	0.1413	0.0321
First American Corp, TN	9,531	0.808	0.0974	0.0260
Old Kent Financial Corp, MI	11,653	0.863	0.1172	0.0225
First Tennessee National Corp, TN	12,104	0.746	0.1098	0.0379
Marshall & Ilsley Corp, WI	13,502	0.802	0.1485	0.0325
First Security Corp, UT	13,567	0.696	0.1073	0.0268
Union Planters Corp, TN	13,870	0.828	0.0920	0.0352
Regions Financial Corp, AL	17,331	0.833	0.1419	0.0226
Fifth Third Bancorp, OH	18,405	0.774	0.2553	0.0570
Huntington Bancshares Inc, OH	19,340	0.671	0.1187	0.0192
Northern Trust Corp, IL	20,064	0.492	0.1237	0.0316
First of America Bank Corp, MI	20,278	0.871	0.0896	0.0233
Crestar Financial Corp, VA	21,082	0.608	0.0985	0.0264
Southtrust Corp, AL	24,488	0.707	0.0982	0.0292
Comerica Inc, MI	31,591	0.699	0.1101	0.0310
Mellon Bank Corp, PA	38,850	0.739	0.0956	0.0398
Corestates Financial Corp, PA	41,799	0.766	0.1361	0.0432
Wachovia Corp, NC	43,143	0.604	0.1518	0.0378
National City Corp, OH	46,424	0.756	0.1228	0.0321
Suntrust Banks Inc, GA	47,588	0.775	0.1380	0.0311
First Chicago NBD Corp, IL	95,612	0.552	0.1113	0.0391
First Union Corp, NC	130,119	0.714	0.0995	0.0263
Nationsbank Corp, NC	172,037	0.633	0.0890	0.0365
JP Morgan & Co. Inc, NY	210,594	0.041	0.0961	0.0144
Citicorp, NY	260,296	0.212	0.0661	0.0293

Table 2

Mean and Median Failure Probabilities for 42 Banks During 1987 – 1996 and During a Steady-State

	Horizon				
	1 Year	2 Years	3 Years	4 Years	5 Years
Risk-Neutral Probability					
Mean, 1987-1996	0.02159	0.01937	0.01801	0.01712	0.01643
Mean, Steady State	0.00834	0.00759	0.00834	0.00924	0.01007
Median, 1987-1996	0.00032	0.00390	0.00708	0.00953	0.01016
Median, Steady State	0.00180	0.00222	0.00294	0.00368	0.00439
Physical Probability					
Mean, 1987-1996	0.01402	0.00913	0.00686	0.00572	0.00481
Mean, Steady State	0.00583	0.00364	0.00319	0.00299	0.00287
Median, 1987-1996	0.00009	0.00100	0.00150	0.00165	0.00161
Median, Steady State	0.00097	0.00074	0.00076	0.00078	0.00075

Table 3

Average Fair and Expected Value Insurance Premiums per $100 of Total Liabilities for 42 Banks During 1987 – 1996 and During a Steady State

	Overlapping Contract Period				
	$n = 1$	$n = 2$	$n = 3$	$n = 4$	$n = 5$
Fair Premium, 1987-1996	0.121	0.137	0.147	0.155	0.160
Fair Premium, Steady State	0.047	0.052	0.056	0.059	0.062
Expected Value Premium, 1987-1996	0.079	0.078	0.075	0.073	0.071
Expected Value Premium, Steady State	0.033	0.031	0.029	0.028	0.027

Table 4

Annual Standard Deviations of Fair and Expected Value Premiums Average across the 42 Banks for 1987-1996 and a Steady State

	Overlapping Contract Period				
	$n = 1$	$n = 2$	$n = 3$	$n = 4$	$n = 5$
Fair Premium, 1987-1996	0.180	0.140	0.111	0.090	0.073
Fair Premium, Steady State	0.166	0.144	0.126	0.113	0.102
Expected Value Premium, 1987-1996	0.123	0.084	0.062	0.047	0.037
Expected Value Premium, Steady State	0.130	0.100	0.081	0.067	0.058

Table 5

Fair and Expected Value Insurance Premiums per $100 Total Liabilities
Averages from 1987 to 1996

	Overlapping Contract Period					
Bank	Fair Premium			Expected Value Premium		
	n = 1	*n* = 3	*n* = 5	*n* = 1	*n* = 3	*n* = 5
Mid America Bancorp, KY	0.000	0.000	0.000	0.000	0.000	0.000
JP Morgan & Co. Inc, NY	0.000	0.000	0.000	0.000	0.000	0.000
Wilmington Trust Corp, DE	0.000	0.000	0.000	0.000	0.000	0.000
Regions Financial Corp, AL	0.000	0.000	0.001	0.000	0.000	0.000
First Virginia Banks Inc, VA	0.000	0.001	0.002	0.000	0.000	0.000
Huntington Bancshares Inc, OH	0.001	0.002	0.002	0.000	0.000	0.000
Mercantile Bankshares Corp, MD	0.001	0.008	0.016	0.000	0.003	0.004
Fifth Third Bancorp, OH	0.001	0.010	0.016	0.001	0.004	0.006
Old Kent Financial Corp, MI	0.002	0.009	0.013	0.000	0.001	0.001
Suntrust Banks Inc, GA	0.002	0.011	0.016	0.001	0.003	0.003
Wachovia Corp, NC	0.004	0.017	0.026	0.002	0.006	0.007
National City Corp, OH	0.004	0.018	0.027	0.001	0.005	0.006
Star Banc Corp, OH	0.006	0.022	0.030	0.002	0.006	0.006
Marshall & Ilsley Corp, WI	0.007	0.021	0.028	0.002	0.006	0.007
Firstmerit Corp, OH	0.008	0.031	0.043	0.004	0.009	0.012
First of America Bank Corp, MI	0.009	0.026	0.034	0.003	0.005	0.005
Northern Trust Corp, IL	0.011	0.028	0.037	0.005	0.009	0.010
Comerica Inc, MI	0.016	0.040	0.050	0.007	0.013	0.014
Southtrust Corp, AL	0.018	0.037	0.046	0.008	0.011	0.011
Commerce Bancshares Inc, MO	0.019	0.051	0.068	0.007	0.012	0.014
First Union Corp, NC	0.020	0.029	0.034	0.008	0.008	0.007
First Chicago NBD Corp, IL	0.027	0.073	0.092	0.014	0.032	0.036
Corestates Financial Corp, PA	0.030	0.065	0.079	0.017	0.031	0.034
First Security Corp, UT	0.037	0.071	0.085	0.014	0.020	0.020
Crestar Financial Corp, VA	0.041	0.049	0.052	0.018	0.014	0.012
Sterling Bancorp, NY	0.042	0.098	0.115	0.018	0.029	0.029
Westamerica Bankcorporation, CA	0.051	0.096	0.120	0.022	0.032	0.034
First Commerce Corp New Orleans, LA	0.071	0.091	0.098	0.026	0.023	0.020
First Citizens Bancshares Inc, NC	0.086	0.121	0.128	0.038	0.036	0.031
Deposit Guaranty Corp, MS	0.099	0.106	0.108	0.046	0.034	0.027
Nationsbank Corp, NC	0.108	0.160	0.180	0.065	0.076	0.075
Hubco Inc, NJ	0.124	0.117	0.112	0.071	0.050	0.040
Trustmark Corp, MS	0.150	0.217	0.242	0.086	0.099	0.096
First American Corp, TN	0.150	0.127	0.123	0.082	0.049	0.036
First Tennessee National Corp, TN	0.165	0.239	0.269	0.095	0.112	0.112
Union Planters Corp, TN	0.218	0.296	0.324	0.128	0.132	0.127
Citicorp, NY	0.258	0.283	0.291	0.150	0.126	0.111
Mellon Bank Corp, PA	0.316	0.344	0.368	0.222	0.202	0.191
Zions Bancorp, UT	0.345	0.432	0.471	0.222	0.235	0.228
Hibernia Corp, LA	0.456	0.395	0.369	0.339	0.231	0.187
Riggs National Corp, DC	0.963	1.057	1.078	0.674	0.580	0.510
Cullen Frost Bankers Inc, TX	1.197	1.396	1.543	0.935	0.910	0.895

Table 6

Fair and Expected Value Insurance Premiums per $100 Total Liabilities
Averages from Steady State

Bank	Overlapping Contract Period					
	Fair Premium			Expected Value Premium		
	n = 1	*n* = 3	*n* = 5	*n* = 1	*n* = 3	*n* = 5
Mid America Bancorp, KY	0.000	0.000	0.000	0.000	0.000	0.000
JP Morgan & Co. Inc, NY	0.000	0.000	0.000	0.000	0.000	0.000
Huntington Bancshares Inc, OH	0.000	0.000	0.000	0.000	0.000	0.000
First Virginia Banks Inc, VA	0.000	0.000	0.000	0.000	0.000	0.000
Regions Financial Corp, AL	0.000	0.000	0.000	0.000	0.000	0.000
Wilmington Trust Corp, DE	0.000	0.000	0.000	0.000	0.000	0.000
Old Kent Financial Corp, MI	0.000	0.001	0.001	0.000	0.000	0.000
First Commerce Corp New Orleans, LA	0.001	0.003	0.006	0.000	0.000	0.001
Commerce Bancshares Inc, MO	0.001	0.006	0.010	0.000	0.001	0.001
First of America Bank Corp, MI	0.002	0.003	0.005	0.001	0.001	0.001
Crestar Financial Corp, VA	0.002	0.005	0.008	0.001	0.001	0.001
Northern Trust Corp, IL	0.002	0.006	0.009	0.001	0.002	0.002
Suntrust Banks Inc, GA	0.003	0.004	0.004	0.001	0.001	0.001
First American Corp, TN	0.003	0.008	0.013	0.001	0.002	0.002
Star Banc Corp, OH	0.003	0.005	0.008	0.001	0.002	0.002
First Union Corp, NC	0.004	0.007	0.009	0.001	0.002	0.002
Deposit Guaranty Corp, MS	0.004	0.010	0.017	0.002	0.002	0.002
Wachovia Corp, NC	0.006	0.008	0.010	0.003	0.003	0.003
Comerica Inc, MI	0.006	0.010	0.014	0.003	0.003	0.003
Westamerica Bankcorporation, CA	0.006	0.012	0.017	0.003	0.003	0.003
Marshall & Ilsley Corp, WI	0.007	0.007	0.008	0.004	0.003	0.002
National City Corp, OH	0.008	0.010	0.013	0.004	0.004	0.003
First Security Corp, UT	0.008	0.013	0.017	0.004	0.003	0.003
Southtrust Corp, AL	0.010	0.014	0.018	0.005	0.005	0.004
Fifth Third Bancorp, OH	0.011	0.012	0.013	0.008	0.007	0.007
Mercantile Bankshares Corp, MD	0.015	0.014	0.014	0.011	0.008	0.006
Hubco Inc, NJ	0.016	0.027	0.036	0.008	0.009	0.010
Sterling Bancorp, NY	0.027	0.038	0.048	0.016	0.014	0.013
Corestates Financial Corp, PA	0.028	0.034	0.039	0.019	0.018	0.017
Firstmerit Corp, OH	0.028	0.028	0.029	0.018	0.013	0.010
First Citizens Bancshares Inc, NC	0.049	0.058	0.067	0.032	0.024	0.020
First Chicago NBD Corp, IL	0.052	0.057	0.062	0.036	0.030	0.027
Mellon Bank Corp, PA	0.055	0.073	0.084	0.037	0.038	0.037
Hibernia Corp, LA	0.064	0.085	0.098	0.043	0.041	0.039
Nationsbank Corp, NC	0.067	0.079	0.087	0.046	0.040	0.036
Citicorp, NY	0.073	0.087	0.097	0.047	0.040	0.035
First Tennessee National Corp, TN	0.098	0.115	0.127	0.068	0.060	0.054
Trustmark Corp, MS	0.111	0.126	0.137	0.077	0.064	0.057
Union Planters Corp, TN	0.117	0.136	0.151	0.078	0.066	0.060
Zions Bancorp, UT	0.166	0.178	0.189	0.121	0.100	0.089
Riggs National Corp, DC	0.362	0.439	0.484	0.258	0.237	0.218
Cullen Frost Bankers Inc, TX	0.548	0.617	0.648	0.429	0.394	0.363

Table 7

Standard Deviations of Fair Insurance Premiums per $100 Total Liabilities Computed from Steady State

Bank	Overlapping Contract Period *n* = 1	*n* = 2	*n* = 3	*n* = 4	*n* = 5
Mid America Bancorp, KY	0.000	0.000	0.000	0.000	0.000
JP Morgan & Co. Inc, NY	0.000	0.000	0.000	0.000	0.000
Huntington Bancshares Inc, OH	0.000	0.000	0.000	0.000	0.000
First Virginia Banks Inc, VA	0.001	0.001	0.000	0.000	0.000
Regions Financial Corp, AL	0.001	0.001	0.000	0.000	0.000
Wilmington Trust Corp, DE	0.005	0.003	0.002	0.001	0.001
Old Kent Financial Corp, MI	0.006	0.004	0.003	0.003	0.003
Commerce Bancshares Inc, MO	0.008	0.011	0.013	0.013	0.013
First Commerce Corp New Orleans, LA	0.009	0.008	0.009	0.009	0.010
Crestar Financial Corp, VA	0.015	0.013	0.013	0.012	0.011
Northern Trust Corp, IL	0.018	0.015	0.013	0.012	0.011
First Union Corp, NC	0.021	0.018	0.017	0.015	0.014
First American Corp, TN	0.024	0.022	0.021	0.020	0.019
Suntrust Banks Inc, GA	0.027	0.019	0.015	0.013	0.011
Star Banc Corp, OH	0.028	0.023	0.020	0.017	0.015
First of America Bank Corp, MI	0.029	0.021	0.016	0.013	0.011
Wachovia Corp, NC	0.039	0.028	0.023	0.019	0.016
Comerica Inc, MI	0.039	0.029	0.024	0.021	0.019
Deposit Guaranty Corp, MS	0.047	0.033	0.029	0.027	0.025
National City Corp, OH	0.052	0.037	0.030	0.026	0.022
Southtrust Corp, AL	0.053	0.041	0.035	0.031	0.028
Westamerica Bankcorporation, CA	0.055	0.042	0.035	0.031	0.028
Fifth Third Bancorp, OH	0.063	0.046	0.036	0.029	0.025
First Security Corp, UT	0.069	0.051	0.039	0.032	0.027
Hubco Inc, NJ	0.078	0.064	0.055	0.048	0.043
Marshall & Ilsley Corp, WI	0.087	0.061	0.047	0.038	0.032
Corestates Financial Corp, PA	0.125	0.101	0.085	0.073	0.065
Sterling Bancorp, NY	0.191	0.147	0.119	0.101	0.087
Mellon Bank Corp, PA	0.192	0.171	0.152	0.136	0.123
Mercantile Bankshares Corp, MD	0.203	0.158	0.122	0.097	0.079
Firstmerit Corp, OH	0.203	0.147	0.114	0.092	0.077
First Chicago NBD Corp, IL	0.216	0.176	0.148	0.128	0.112
Nationsbank Corp, NC	0.237	0.200	0.172	0.151	0.135
Citicorp, NY	0.269	0.248	0.227	0.208	0.191
Hibernia Corp, LA	0.304	0.249	0.209	0.179	0.157
First Citizens Bancshares Inc, NC	0.364	0.332	0.297	0.264	0.235
First Tennessee National Corp, TN	0.435	0.392	0.351	0.318	0.287
Trustmark Corp, MS	0.448	0.364	0.304	0.263	0.230
Union Planters Corp, TN	0.450	0.368	0.310	0.266	0.232
Zions Bancorp, UT	0.582	0.491	0.422	0.367	0.324
Riggs National Corp, DC	0.902	0.874	0.826	0.778	0.732
Cullen Frost Bankers Inc, TX	1.097	1.033	0.955	0.883	0.820

Figure 1

An Example of Five Overlapping Contracts

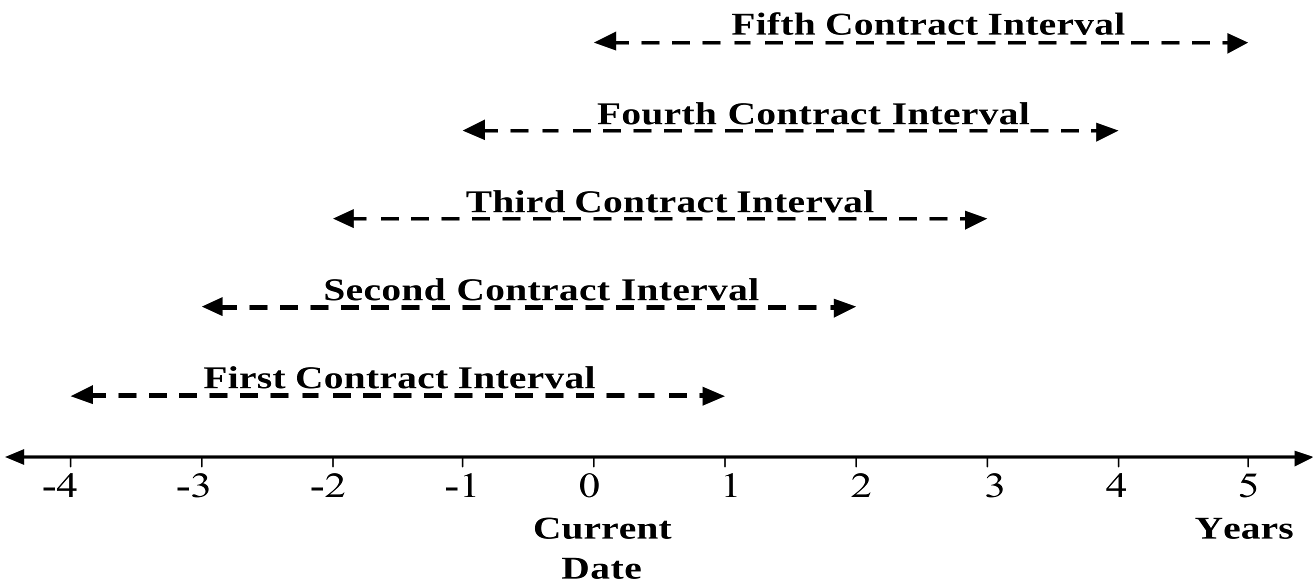
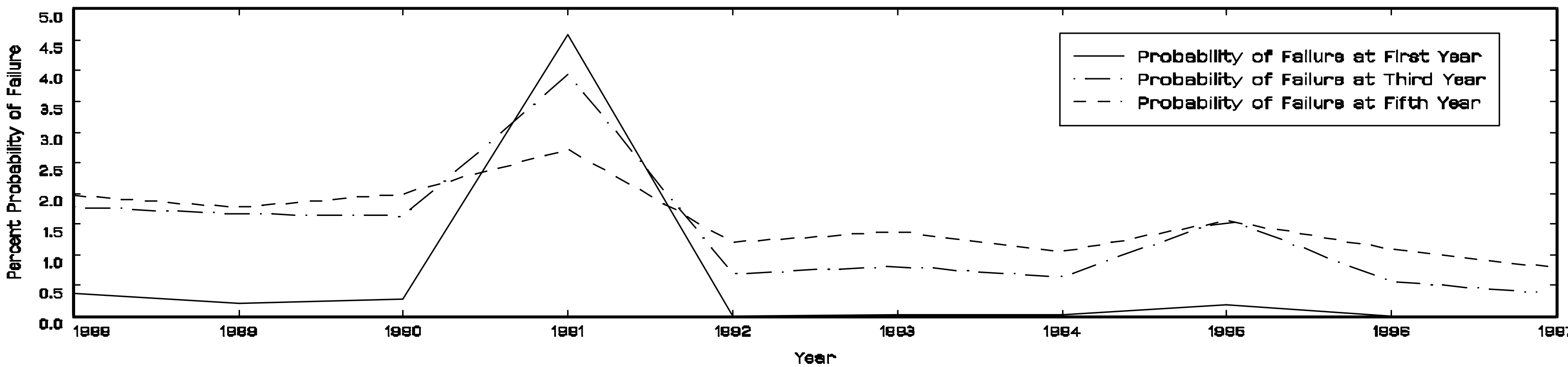


Figure 2

Risk Neutral Failure Probabilities for Median Bank



Risk Neutral Failure Probabilities for 75th Percentile Bank

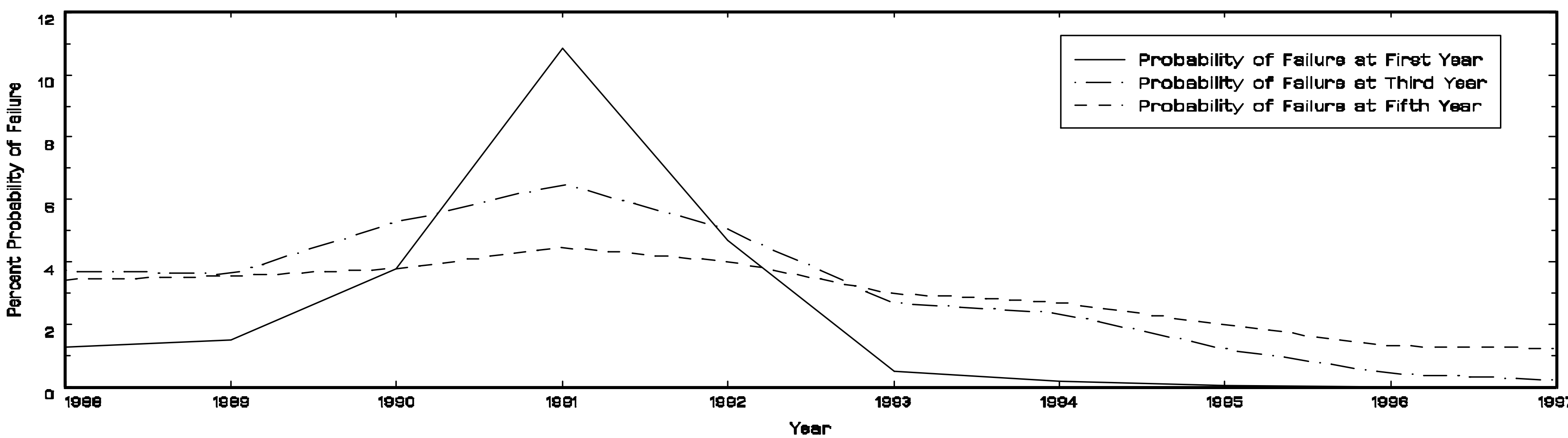


Figure 3

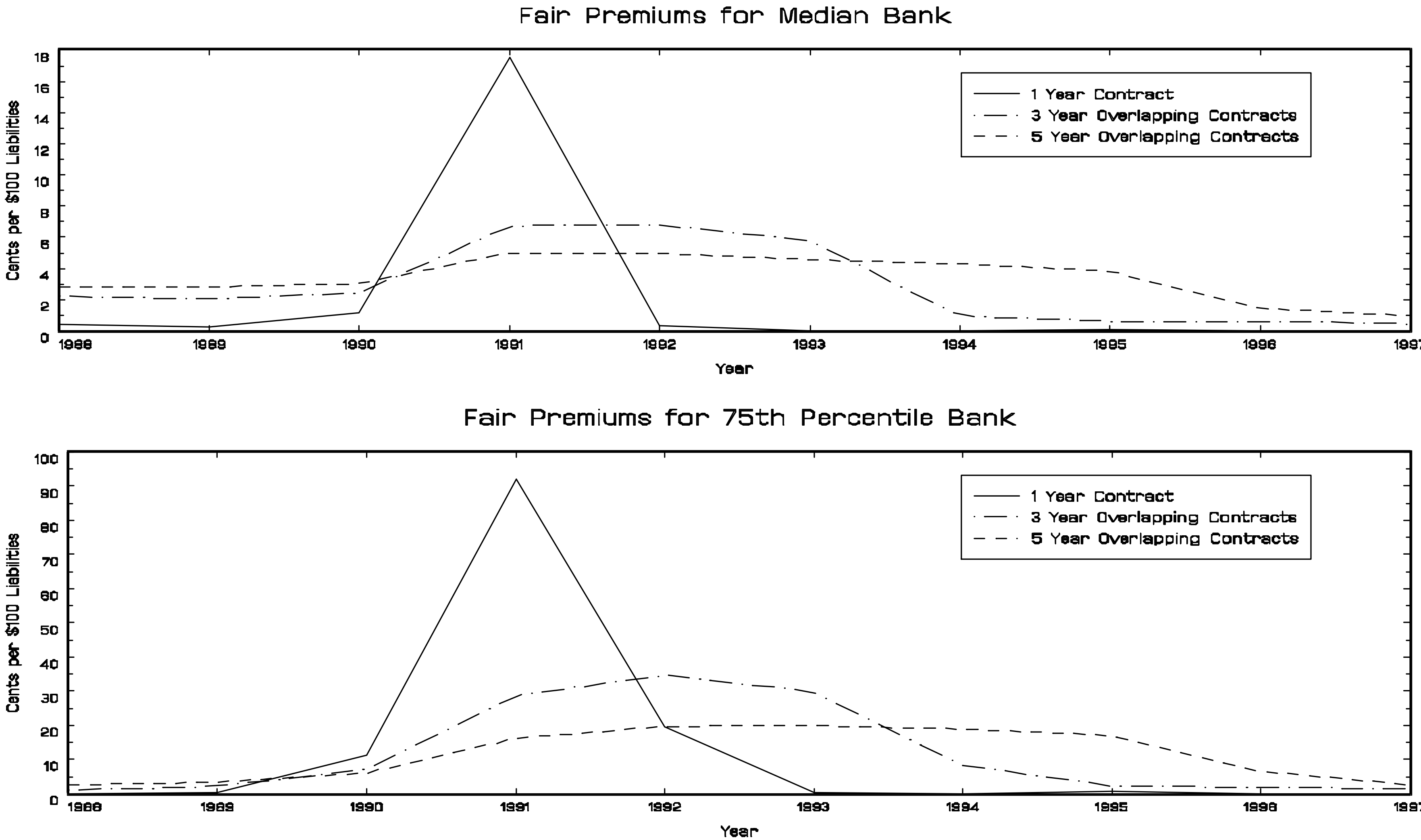

Fair Premiums for Median Bank
1 Year Contract
3 Year Overlapping Contracts
5 Year Overlapping Contracts
Cents per $100 Liabilities
0
2
4
6
8
10
12
14
16
18
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
Year
Fair Premiums for 75th Percentile Bank
1 Year Contract
3 Year Overlapping Contracts
5 Year Overlapping Contracts
Cents per $100 Liabilities
0
10
20
30
40
50
60
70
80
90
100
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
Year

Figure 4

Convexity of Option Premium Implies $\left[1-P(x,1)\right]/x<\partial P(x,1)/\partial x$